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Investigating Slip, Trip and Fall Mishaps

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This article focuses on common tools, methods of data collection, and different analyses used in conducting a slip, trip and fall investigation to arrive at causation within a reasonable degree of scientific certainty. While many slip, trip and fall investigations are similar, no two are identical. Therefore it would be impossible to address every aspect of their investigation.

Conducting a comprehensive slip, trip and fall investigation is analogous to conducting an experiment following sound scientific protocols. The investigator collects data (case evidence), develops a hypothesis, and conducts an analysis to test the hypothesis. The analysis ultimately allows the investigator to arrive at a conclusion with a reasonable degree of scientific certainty as to the cause of the fall incident. For example, if a fall incident was alleged to be the result of a slippery walking surface due to water contamination, the hypothesis would be: "did the wet surface cause the fall?" The investigator would then collect data in the form of friction measurements. Should the measurements show adequate friction under wet conditions, the hypothesis would not be supported by the data. However, if the friction measurements showed inadequate friction, the hypothesis that the wet floor caused the incident would be ruled in. After other plausible factors are ruled out, the investigator can reach the final conclusion of the wet floor being the cause of the accident.

The following sections discuss various data collection tools and methodologies for conducting a slip, trip, and fall investigation. It is assumed that the reader has a general understanding of the various analyses for which data will be used. Only general references to specific analyses are made since detailed discussions are beyond the scope of this article. References are provided for further detail of these analyses.

Photographs

Perhaps the most common method of collecting data is photographing the incident site. Photographic documentation has three goals: capture the "big picture," document the specific items of interest, and assess the claimant's view. Photographs provide a means to objectively capture, communicate, and document the entire environment and surroundings of the incident site. They can provide an approximate perspective of what the claimant saw and did not see, as well as detail specific items of interest. The investigator must be aware, however, that site conditions change over time, and photographs taken at the site inspection do not necessarily represent the site on the day of the incident.

Overall scene photographs are taken to capture the "big picture" and should be taken, if possible, prior to any detailed investigative work. Take photographs from as many angles as possible to capture a 360 degree view. Do not just take photographs from the claimant's point of view. For instance, if an incident involves a fall while descending stairs, do not only take photographs looking down the stairs, take photographs from below looking up to get a view of where the person came from. These photographs are extremely useful for visually communicating the incident scenario to other parties which may ultimately include a jury.

The second goal is to photograph specific elements of interest. These photographs are typically in the form of close-ups, with or without a scaling device such as a tape measure or something of known dimensions. Make sure to take an establishing photograph with the close-ups, since the 3rd step of a stairway will look the same as the 10th step close up. If photographs are taken with a measurement device in the photograph and the measurement is visually observed and recorded, the investigator needs to be aware of potential discrepancies between the two. These discrepancies tend to arise from differences between the angle at which the photograph was taken and the angle at which the measurement device was observed.

The third goal is to photograph the line of sight that reflects the claimant's view. These photographs are useful in conducting a visibility analysis to assess whether a person should have seen an obstacle. If the claimant's eye height is an important consideration, then the eye height can be estimated by subtracting the distance from the top of the head to the eye[1] from the claimant's over all height.

Linear/slope Measurements

The tape measure is likely the next most common instrument used in a slip, trip and fall investigation. My recommendation is to have four types of tape measures: a 10-foot, a 25-foot, a carpenter's square, and a measuring wheel. The smaller 10-foot tape measures are far easier to hold while taking photographs than the heavier 25-foot tape measures. The carpenter's square works well for measuring step treads and risers. Yellow inch tape paced along the scales of the carpenter's square enhances the scale's clarity in the photographs since the original engraved scales tend not to show up clearly in photographs. A clamp used in conjunction with the carpenter's square works as a third hand. The roller wheel measures larger distances such as the length of a parking lot. This data is useful in conducting a gait analysis, which can show that someone walking across a 50-foot long parking lot had adequate time to observe a given hazard.

The slope of a ramp surface can be made by measuring the rise/run and/or direct measurements. For direct measurements, the electronic level works well. These electronic levels typically have features that allow the units to be changed between degrees, % slope and rise/run. The home style laser levels (or flash lights with a laser) work well for measuring the rise and run dimensions of the slopped walkway. It is always a good idea to carry the traditional inclinometer as a backup.

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[1] Woodson, W.E. (1992). Human factors design handbook. McGraw-Hill, NY

Other Accessories

Other useful investigative tools include a plum bob, string, thin masking tape, and Post-it® notes. The plum bob, string, and thin tape work well for defining reference lines or laying out a grid for conducting a lighting survey. Post-it® notes come in handy to make title boards for photographing. No matter how obvious things seem at the time of the inspection, two weeks later you are going to be wondering if the photograph was taken on the 3rd or 4th floor.

Measuring Elevation Differentials

Measuring changes of elevation is of prime importance in investigating trip mechanisms. Typically a tape measure is used to measure the height of an elevation difference in a sidewalk. This measurement can be prone to an error if not viewed directly at a right angle. This is also true for photographing this measurement. Alternatively, a profile gauge can be used. The measurement can be directly taken off the profile gauge. The profile gauge offers the additional advantages of being able to trace the elevation difference profile onto graph paper and photographing the gauge. The profile gauges also work well for documenting the height of door thresholds. Profile gauges are made with either plastic or metal rods, but plastic rods do not get bent and fall out. While the metal rods give a very fine resolution, the plastic ones provide adequate resolution for most analyses.

Light Meters

Light surveys require the use of a calibrated light meter. A number of manufactures offer easy to use and affordable light meters for field measurements. An initial step in conducting a light survey is to develop a grid in the in the area of interest. This may entail taking three readings across the nosing of a step or 50 readings in a parking lot. The investigator needs to ensure that the lighting conditions at the time of the inspection reflect those at the time of the subject incident. The lighting analysis then entails comparing the light survey to accepted standards and design guidelines such as the guidelines for illumination values provided by the International Building Codes and Illuminating Engineering Society of North America.

Weather Data

Weather data can be obtained through the NOAA (National Oceanic and Atmospheric Administration) government agency web site. The following link to the specific page with instructions for purchasing NOAA products is included for easy reference (http://ols.nndc.noaa.gov/plolstore/plsql/olstore.main?look=1). This web site has more climatology data than you will mostly likely ever need, as most investigations will only require surface-type observations. The cost for weather data from an individual station is on the order of $3 to $4. For more complex questions regarding weather, weather consultants can conduct the research and provide data interpretation.

1. Select **climate**
2. Select **surface weather observations**
3. Select **online individual station**
4. Select appropriate **date** for database
5. Select **state**
6. Select **weather station** designated by city
7. Select **year** and **month**
8. Select **day**
9. Proceed to checkout
10. Access data online

Biomechanical Data

Biomechanical analyses in slip, trip, and fall investigations offer the investigator means to assess both liability and damages of a slip, trip, and fall incident. A full discussion of a biomechanical analysis is beyond the scope of this article but many treatises have been written specifically on this subject.[2,3] A biomechanical analysis essentially evaluates the consistency between the injury and fall kinematics and fall mechanism. For example, abrasions to the front part of the knee would be expected to occur from a forward fall as a result of a trip and not a slip. Some biomechanical analyses, such as this example are relatively straightforward while others, such as a trimalleolar ankle fracture, require the involvement of biomechanist with specialized training. Data for biomechanical analysis including age, height, weight, pre-existing conditions, incident description and injury descriptions are gleamed from the medical records. The height and weight can typically be found on nutritional evaluations, anesthesiology records, and intake forms. Pre-existing conditions are typically found in the narrative sections. The best sources for the injury descriptions are in the discharge summary, radiology reports, and operative reports.

Slip Resistance

Slip incidents typically entail measuring the slip resistance (or static coefficient of friction) of a walkway. Many detailed treatises have been written specifically on this subject.[4,5,6] [Note: The terms static coefficient of friction and slip resistance are often used interchangeably. While the term coefficient of friction is frequently used, the term "slip resistance" is more appropriate in a

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2 Gushue, D. L. et al. (2007). *Biomechanics for Risk Managers-Analyses of Slip, Trip & Fall Injuries*. Proceedings of the 2007 ASSE Professional Development Conference. Orlando, FL: ASSE.

3 Joganich T. (2006). *Biomechanical Analysis in Slip, Trip, Stumble, and Fall Incidents*. Proceedings of the 2006 ASSE Professional Development Conference. Seattle, WA: ASSE.

4 Marpet, M.I. (1996). On threshold values that separate pedestrian walkways that are slip resistance from those that are not. Journal of Forensic Science, 41(5), 747-755.

5 Marpet, M.I. & Sapienza, M.A. (Eds.) Metrology of pedestrian locomotion and slip resistance. (pp 3-16). ASTM Stock Number: STP1424. West Conshohocken, PA: ASTM.

6 Di Pilla, S. and Vidal, K. (June 2002). State of the art in slip resistance measurements. A review of current standards and continuing developments. Professional Safety. Journal of the American Society of Safety Engineers. 47(6). American Society of Safety Engineers Des Plaines, IL.

slip and fall investigation since it refers to the frictional forces that impede the foot from sliding forward during heel contact] The slip resistance of a walkway surface is most commonly measured with an instrument called a tribometer. These devices measure the ratio of the horizontal and normal forces that cause a test surface to slip. While a number of tribometers exist for measuring the slip resistance of walkway surfaces under dry conditions, only the English XL and Brungraber Mark II have been proven reliable for testing under contaminated conditions.[7] This reliability is due to the operational characteristics of these devices that allow the test surface to be positioned above the walkway surface prior to applying the loads, as opposed to other devices that rest on the walkway surface prior to loading. The latter method can provide erroneous readings due to the surface adhesion. One must also consider that slip resistance testing under dry conditions does not typically have any relevance to investigating a slip and fall incident, because it is very rare that someone will slip under "dry" conditions. For this reason measuring the slip resistance of a walkway under contaminated conditions with either the English XL or Brungraber Mark II is more meaningful for determining the validity of a purported slip.

The interpretation of slip resistance readings is worth noting and has been debated in the walkway safety community.[8] A slip resistance value of 0.5 and greater is often cited as providing an adequate amount of friction for normal level walking.[9] Conversely, a slip resistance value of less than 0.5 is sometimes used to indicate a dangerous and slippery floor surface. The ASSE/ANSI 1264.2-2001 Standard for the Provision of Slip Resistance on Walking/Working Surfaces has taken the position that floors with a slip resistance of less than 0.5 are necessarily a slip hazard. Specifically it states that "*floors, which do not meet the 0.5 guideline for dry conditions, should not be considered to be inherently dangerous*." This is consistent with the plethora of biomechanical data showing that human gait requires on the order of 0.2 to 0.3.[10]

Witness Statements

Witness statements can be obtained from both the claimant and the witnesses. It is important to gather as much detail as possible in a number of areas. The inquiry should focus on the events leading up to the incident such as walking speed, objects being carried, and distance walked after turning a corner. Such details are helpful in conducting an analysis to determine how much time someone had to view the surroundings prior to a fall. The inquiry should also focus on the fall mechanism (i.e. slip, trip, or misstep) and the fall kinematics (i.e. forward or rearward fall). These details are invaluable for assessing the validity of the described kinematics. The inquiry should include fall kinematics with regards to ground contact, such as "did you head or buttock contact the ground?" Such data is important for a biomechanical analysis.

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7 Ibid.

8 Marpet, M.I. (1996). On threshold values that separate pedestrian walkways that are slip resistance from those that are not. Journal of Forensic Science, 41(5), 747-755.

9 Miller, J.M. (1983). "Slippery" work surfaces: towards a performance definition and quantitative coefficient of friction criteria. Journal of Safety Research, 14, 145-158.

10 Redfern, M.S. et al. (2003) Biomechanics of slips. In Chang WR & Courtney T.K (Eds.) Measuring Slipperiness. Taylor & Francis, New York.

Analyses

After the data is collected, the investigator can conduct various analyses to evaluate the potential causative factors. The investigator should consider three broad categories of causative factors: extrinsic, intrinsic, or system. Extrinsic factors include the physical environment design such as riser and tread dimensions. Intrinsic factors include haste, inattention, and injuries. System factors could be things like weather, warnings, maintenance, and other such items. As previously discussed, the data is evaluated in the context of a hypothesis. For example: did the excessively high riser cause the trip?

Extrinsic factors are analyzed by comparing a dimensional aspect(s) of the environment that is alleged to be proximate to the fall incident with building codes, design standards and good design practices. The question that is typically at issue is whether a particular dimensional aspect of an architectural element, such as a riser height, complies with codes and standards, and is consistent with good design practices. Residential codes are generally less stringent than commercial and industrial codes. Most common is the International Code Council (ICC) Building Code. The particular version of the code that was in effect at the time of construction can usually be obtained through the township/city office. Other commonly referenced codes and standards include:

- American Society of Testing Materials (ASTM) 1637 – Standard Practice for Safe Walking Surfaces
- ASSE/ANSI 1264.2-2001
- OSHA
- ANSI–117.1 Accessible and Accessible and Usable Buildings and Facilities.[11]

One must also consider whether or not the “defect” was proximate to the fall. The existence of a “defect” at the time of a fall incident does not does not necessarily mean that it was proximate to the fall incident. While determining whether or not a dimension is within code is typically straightforward, the harder question is whether some “defect” is insignificant. The analysis must consider other factors such as user expectations and incident history.

Intrinsic factors are analyzed by human factors and/or biomechanical analyses. The human factors analysis takes into account the human’s capabilities and expectations while interacting with an environment. Human factor analyses cover a broad range of analyses and are discussed in the literature.[12,13] Examples of such analyses include visibility analysis to determine whether the person should have seen the step or whether his attention was distracted. As previously discussed, biomechanical analyses assess the consistency between the fall mechanism, fall kinematics, and subsequent injuries. These analyses are used to determine if the injuries are consistent with the described fall or whether a person had a reasonable amount of time to observe a caution sign. This latter example entails using a distance measured at the scene and a gait speed from

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11 The reader is cautioned that this standard specifically addresses accessibility and references to safety should be done judiciously.

12 Templer, J. (1994) The Staircase, studies of hazards, fall and safer design. Massachusetts Institute of Technology.

13 Sanders, M.S. and McCormick, E.J. (1993). Human factors in engineering and design: Seventh edition, McGraw-Hill, NY.

biomechanical gait data to determine a time, highlighting the importance of collecting the appropriate data; i.e., distance data from the site inspection and walking speed from statements/depositions. It is helpful to use references containing gait speed, step length and step frequency for various age groups.[14]

System factors are analyzed with a variety of data from weather data to cleaning records. The analysis typically evaluates whether or not a property owner acted reasonably to ensure a safe premise. In other words, while all walking surfaces should be free of hazards, it is the reasonableness of ensuring that the walking surfaces are free from hazards that is often called into question. Conducting a system factors analysis typically entails reviewing maintenance logs for frequency of inspection and repair, and evaluating them within the context of the particular circumstance and industry practices. For example, a reasonable frequency for monitoring a crowded grocery store floor for slip and trip hazards is certainly different than a reasonable frequency for monitoring an infrequently used warehouse. For snow and ice conditions, many townships publish their ordinances indicating specific times for removing snow and ice from sidewalks after a snow fall.

In summary, a description of the scientific methodology for investigating a slip, trip and fall incidents is provided above. This methodology entails developing hypotheses and then testing them by collecting data with any number of tools and then analyzing the data. This methodology will allow the investigator to arrive a conclusion as to the causative factor(s) to a fall incident to a reasonable degree of scientific certainty.

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[14] Öberg T. et al. (1993). Basic gait parameters: reference data for normal subjects, 10-79 years of age. Journal of Rehabilitation Research and Development, 30(2), 210-223.